Discussion Paper No. 885

TIME DISCOUNTING, PRESENT BIASES, AND HEALTH-RELATED BEHAVIOR

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September 2013

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9 September 2013

[*] Our thanks go to participants at the Economics Workshop on Dynamics and Human Behavior held at Hiroshima University, 2013, for helpful comments. We acknowledge financial supports from: a Grants-in-Aid for Scientific Research (B No. 21330046) from the Japan Society for the Promotion of Science; the Global COE Program of Osaka University; and the Joint Usage/ Research Center Project of ISER from the Ministry of Education, Culture, Sports, Science and Technology.

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Abstract

Analysis of an original nationwide Internet survey reveals that health-related behavior shows associations with three aspects of time discounting: (i) impatience, measured by the overall discount rate; (ii) present bias, measured by the degree of declining impatience in the generalized hyperbolic discount function; and (iii) the sign effect, in that future losses are discounted at a lower rate than future gains. Present-biased respondents are classified as naïve if the responses are indicative of being a time-inconsistent procrastinator, and classified as sophisticated otherwise. The health-related indicators that we examine relate to smoking, health condition, dentition status, and body habitus. We first show that a higher degree of impatience tends to worsen health-related attributes. Second, respondents with more steeply declining impatience tend to develop more unhealthy behavior and ill-health conditions, and the tendencies are likely to be stronger for naïfs than for sophisticates. Third, the sign effect, too, shows an association with health-related behavior, although the significance levels are not overly high. Consistent with these findings, the principal component of the health-related measures shows strong associations with the degrees of impatience and declining impatience.

Keywords: health, time preference, discount rate, hyperbolic discounting, the sign effect, the probit model

JEL classification: I1, D03, D90

1. Introduction

This study focuses on the associations of health-related behavior with three aspects of time discounting: (i) impatience, (ii) hyperbolic discounting or declining impatience, and (iii) the sign effect. To do so, we conduct an original nationwide Internet survey of Japanese adults that includes questions that help us measure respondents' behavioral inclinations with respect to time discounting.

Since Grossman (1972) proposes a health investment model, health-related choices are considered intertemporal decision making, such that, for example, consumers allocate their resources to maximize their discounted utility under trade-offs between a small and immediate reward (e.g., eating high-calorie meals) and a larger delayed reward (e.g., enjoying future good health), or between an immediate payment (e.g., exercise or routine medical checkups) and a larger delayed payment (e.g., suffering from lifestyle-related diseases such as obesity and diabetes). Therefore, the degree of impatience is predicted to correlate with current health-related behavior—such as caloric intake, dental care, and smoking—as well as resulting health statuses, such as BMI, dentition status, and subjective health condition.[1]

Behavioral economics, in the meanwhile, finds two behavioral properties in people's time discounting: hyperbolic discounting, where a person applies a higher discount rate in immediate future choices than in distant future choices, and the sign effect, where a person discounts positive pay-offs more intensely than negative pay-offs (e.g., Thaler, 1981; Benzion *et al*., 1989; Chapman, 1996). Hyperbolic discounters would sacrifice their future health for small immediate pleasures (e.g., Ainslie, 1992; Gruber and Kőszegi, 2001; Chabris *et al*., 2008; Ikeda *et al*., 2010; Kang and Ikeda, 2010). People with the sign effect, in contrast, would be strongly reluctant to bear the future cost of lost health for immediate gratification (Odum *et al*., 2002; Ikeda *et al*., 2010; Kang and Ikeda, 2010). Despite the fact that logical and testable predictions of health-related behavior are developed, there are few attempts at direct and systematic empirical confirmation.

We test the associations between time preferences and health-related behavior by eliciting three measures for time-discounting properties (i.e., impatience, declining impatience, and the sign effect) from

[1] The study of Fuchs (1980) is the first to detect relationships between individual impatience and health-related behavior. For brief surveys, see Chapman (2003) and Cawley and Ruhm (2011).

four hypothetical questions regarding intertemporal choices. Hyperbolic discounters are sorted into sophisticates and naïfs by posing questions about planning and doing homework assignments in childhood. As a result, we show that time-preference measures widely relate to health-related decisions and current health statuses, such as smoking, being obese or underweight, subjective health status, and dentition status.

The contributions of this study are threefold. First, we specify the discount factor in the form of a "generalized hyperbolic discount function" (Loewenstein and Prelec, 1992), which is characterized by two parameters: the degree of hyperbolic deviation from exponential discounting (α) and the determinant of the intercept (η). We adduce the two parameters for each individual from responses to hypothetical questions regarding immediate future choices and distant future choices. Each individual's α measures his or her degree of declining impatience. We find that this measure is associated with health-related behavior in the manner predicted. The individual's degree of impatience is constructed by combining the inferred individual values of parameter η with other discount rates.

Second, by jointly incorporating the three time-discounting variables as regressors, this research detects partial associations between each time-discounting property and health-related behavior. In this sense, the current study sharply contrasts with previous empirical studies, which merely focus on either aspect of the time-discounting properties.[2] This difference is important, because the three time-discounting properties are not mutually exclusive (e.g., hyperbolic discounters can be less patient in terms of the overall discount rate and may or may not show a gain–loss asymmetry in discounting).[3] Our set of inquires enables us to focus simultaneously on the multifaceted nature of time discounting.[4]

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[2] The study of Grignon (2009) is a typical example: to compare smoking decisions among the types of time discounting, it classifies respondents into impatient, patient, *and* present-biased agents. Chabris *et al*. (2008) focus on the association between the degree of declining impatience and health behavior, without incorporating the other time-discounting properties.

[3] In our dataset, 28.3% of respondents (N = 543) display below-average discount rates, while showing both the hyperbolic property and the incidence of the sign effect.

[4] Based on a similar motivation, we also detect partial associations of the three time-discounting properties with body mass index—defined as weight in kilograms divided by height in meters squared (kg/m^2), debt-holding behavior, and cigarette consumption. See Ikeda *et al*. (2010), Ikeda and Kang (2011), and

Third, our study partially succeeds in detecting the inclinations of naïve hyperbolic discounters toward worse health statuses. Economic theory has shown that in many cases, time-inconsistent over-consumption behavior due to hyperbolic discounting is more salient for naïfs, who misperceive their self-control problem, than for sophisticates, who incorporate the effect of the problem into their decision making. In the context of health decisions, it is predicted that naïve hyperbolic discounters have greater inclinations toward ill health statuses than sophisticated hyperbolic discounters and exponential discounters.[5] Irrespective of the predictions, there have been few attempts to test their empirical validity. By sorting hyperbolic respondents into naïfs and sophisticates, the current study fills this research gap.

The present research generates the following three findings. First, a higher degree of impatience worsens health-related attributes; second, steeply declining impatience or a present-biased preference leads respondents to more unhealthy behavior, or to ill-health conditions, and such behavioral impacts are stronger for naïfs than for sophisticates; and third, the sign effect shows associations with health-related attributes, consistent with our prediction, although the levels of statistical significance are weak.

The remainder of this paper is constructed as follows. Section 2 briefly discusses the theoretical relationship between time discounting and health-related behavior, and explains the data. Section 3 shows the empirical results. Finally, Section 4 concludes the paper.

2. Data and hypotheses

Our research detects the empirical associations between health-related behavior and three aspects of time discounting: (i) hyperbolic discounting, (ii) impatience, and (iii) the sign effect. To do so, the original nationwide Internet survey “Japan Internet Survey on Preferences Relating to Time and Risk” (hereafter, JPTR) is used. The JPTR was conducted from October 21 to 27, 2010, through Nikkei Research, Inc., a

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Kang and Ikeda (2010).

[5] Indeed, in the context of the smoking decision, Gruber and Kőszegi (2004) theoretically show that naïve hyperbolic discounters have a higher smoking propensity than sophisticated hyperbolic discounters and the exponential discounters, whereas the difference in smoking propensity between sophisticated hyperbolic discounters and exponential discounters is not overly large.

representative private research company that handles economic surveys. The respondents are 2,386 Japanese adults aged 20–65 years, selected by stratified random sampling from the Nikkei Research Access Pane that comprises a total of about 155,000 individuals, such that the age–gender distribution is as close as possible to that of the Japanese census.[6] As incentives, cash vouchers are provided to respondents by lottery.

Various questions are contained in the JPTR to elicit time and risk preferences, health-related behavior, health conditions, and respondents' economic, demographic, and social attributes such as income, asset holdings, gender, university degree, and age. Panel A of Table 1 shows the summary statistics of background attributes of the respondents: males comprise 49.9% of all respondents, and the average age overall is 41.8 years.[7]

Insert Table 1

2.1. Health-related variables

Several health-related questions asked in the JPTR are listed in Table 2. We construct six indicator variables from these questions for the explained variables.

Insert Table 2

A smoking indicator, SMOKING, is created from FQ1, such that it equals 1 if respondents report the consumption of more than 10 cigarettes per day, and 0 otherwise.[8] From responses to questions about the

[6] During the survey period, 11,090 registrants were notified about the survey by e-mail.

[7] To elicit the degree of risk aversion, we asked respondents to make three sequential binary choices, as in Figure 1 for discount rates, on whether they play lottery "A" that pays out JPY100,000 (USD1,233) with probability 0.5 at given prices, specified as JPY10 to JPY50,000.

[8] In all, 500 respondents who chose option (vii) in FQ1 (i.e., have quit smoking) are excluded from our analysis.

respondents' height and weight in FQ2, we calculate BMI values and identify obese and underweight adults by creating three binary indicators: OBESITY, which takes the value of 1 if BMI $\geq$ 25, and 0 otherwise; SEVERE OBESITY, which takes the value of 1 if BMI $\geq$ 30, and 0 otherwise; and UNDERWEIGHT, which takes the value of 1 if BMI < 18.5, and 0 otherwise.[9] As an indicator of subjective health status, HEALTH is created from FQ3, which takes the value of 1 if a respondent selects a value equal to or greater than six, and 0 otherwise. Finally, a binary indicator, HEALTHYTEETH, takes the value of 1 if a respondent has such good dentition that he or she has kept all permanent teeth (i.e., people select option (i) in FQ4), and 0 otherwise.

Panel B of Table 1 shows the summary statistics of health-related indicators: smokers account for 17.2% of all respondents; obese people, very obese people, and underweight people comprise 18.1%, 3.1%, and 11.5% of the respondents, respectively; 72.6% of the respondents rate their own health status as being six points or higher on a 10-point scale, from 1 to 10; and respondents with a healthy dentition status comprise 65.2% of the total.

2.2. Time preferences

In the JPTR, four questions on intertemporal choices were asked to determine the nature of the respondents' time discounting: two (Q1 and Q2) were designed to detect the degree of declining impatience; the other two (Q5 and Q6) were asked to detect the incidence of the sign effect. The degree of impatience is measured by combining the four questions. Respondents are classified as sophisticates or naïfs, based on the degree of difference between their planned and actual behavior with respect to their imposed tasks.

2.2.1. Hyperbolic discounting (declining impatience)

Consider that the consumers' discount factor for future felicity with delay τ is given by the generalized

[9] Such criteria regarding bodily habitus are provided by the Examination Committee of Criteria for "Obesity Disease in Japan," which is affiliated with the Japan Society for the Study of Obesity (JSSO).

hyperbolic discount function $f(\tau)$:

$$f(\tau;\alpha,\eta)=(1+\alpha\tau)^{-\eta},\ \ \tau\geq 0,\alpha\geq 0,\eta\geq 0. \tag{1}$$

According to the definition of the discount rate ρ that equals $-f'(\tau)/f(\tau)$, it can be calculated as follows:

$$\rho(\tau;\alpha,\eta)=\frac{\alpha\eta}{1+\alpha\tau}. \tag{2}$$

In equation (2), the discount rate is declining in delay τ, which represents the usual property of hyperbolic discounters: such individuals are less patient in immediate future choices than in distant future choices (e.g., Ainslie, 2001; Benzion *et al*., 1989). Here, the parameter α indicates the *degree of declining impatience*: as α increases, the degree of declining impatience is higher. Especially, the relative discount rates $\rho(\tau_1)/\rho(\tau_2)$ $(=(1+\alpha\tau_2)/(1+\alpha\tau_1))$ for two distinct delays τ_1 and τ_2 $(\tau_1>\tau_2)$, which are smaller than 1, depend solely on α (i.e., a larger α implies a smaller $\rho(\tau_1)/\rho(\tau_2)$), with it leading to a stronger present-biased preference.

To elicit the degree of declining impatience α, we use the two JPTR questions Q1 and Q2, which sequentially propose three queries of binary choices on immediate future and distant future trade-offs, respectively. Figure 1 shows tree diagrams that illustrate the sequential queries.

Insert Figure 1

In Q1, respondents are asked to choose between (A) receiving JPY1,000 (around USD12.33) today, and (B) receiving JPY1,000 plus a certain additional amount one week later. In Q2, on the other hand, the options are (A) receiving JPY1,000 one year later, and (B) receiving JPY1,000 plus a certain additional amount one year and one week later. Let X_{Q1} and X_{Q2} be the delayed monetary amounts in Q1 and Q2, respectively, which are taken as subjectively equivalent to JPY1,000 in options (A). Then, the degree of declining impatience α in equation (1) is obtained by solving jointly

$$1{,}000 = X_{Q1}\, f(7,\ \alpha,\ \eta),$$
$$1{,}000\ f(365,\ \alpha,\ \eta) = X_{Q2}\, f(372,\ \alpha,\ \eta),$$

which are combined into a nonlinear equation of α,

$$\frac{\ln(1000)-\ln(X_{Q1})}{\ln(1000)-\ln(X_{Q2})}=\frac{\ln(1+7\alpha)}{\ln(1+365\alpha)-\ln(1+372\alpha)}.$$

The sample mean of estimated α takes the value of 0.018, which differs significantly from 0 ($p < 0.00$). As a positive α implies declining impatience or present-biased preferences, it is determined that an average respondent in our sample is present-biased. Respondents with present-biased preferences (i.e., with a positive α) comprise 40.2% (N = 960) of the 2,386 respondents.

Naïfs and sophisticates

We place hyperbolic discounters into two categories, in terms of their self-awareness of the time-inconsistent property inherent in their behavior: *sophisticated* hyperbolic discounters, who are aware of their own time inconsistency which is wrought by hyperbolic discounting, and *naïve* hyperbolic discounters, who misconceive themselves as being time-consistent. Economic theory has shown that in many cases, time-inconsistent over-consumption behavior due to hyperbolic discounting is more salient for naïfs than for sophisticates. Sophisticates behave time-consistently by incorporating the effect of a preference reversal in time discounting, whereas naïfs do not take their self-control problem into account, and hence, they are likely to consume excessively in a time-inconsistent way.[10] We hypothesize that hyperbolic discounters are more likely to show inclinations toward ill health than exponential discounters, and that the tendency is stronger for naïve hyperbolic discounters than for sophisticated hyperbolic discounters.

To classify each of the hyperbolic respondents as being naïfs or sophisticates, we pose two questions as to (i) how respondents used to do homework assignments during their childhood vacations, and (ii) how they had planned to do them:

[10] Behavioral differences between naïfs and sophisticates are discussed in terms of procrastination behavior, by O'Donoghue and Rabin (1999); borrowing behavior, by Heidhue and Kőszegi (2010) and Ikeda and Kang (2011); and smoking behavior, by Gruber and Kőszegi (2004) and Kang and Ikeda (2010).

Q3. Reflecting back on when you were a child and you were given an assignment to be completed during the school vacation, how early did you usually finish the assignment? (Mark the appropriate box with an "X.")

(i) Did it right away

(ii) Tended to get it done early, before the due date

(iii) Worked on it daily up until the due date

(iv) Tended to get it done toward the end

(v) Got it done at the last minute

Q4. Reflecting back on when you were a child and you were given an assignment to be completed during school vacation, how early did you plan to finish the assignment? (Mark the appropriate box with an "X.")

(i) I planned to get it done right away

(ii) I planned to get it done rather early, before the due date

(iii) I planned to work on it daily up until the due date

(iv) I planned to get it done closer toward the end

(v) I planned to get it done at the last minute

(vi) I didn't make any plans

After excluding 109 hyperbolic respondents who chose option (vi) in Q4 (i.e., who had not made any plans), we identify present-biased respondents (that is, those with $\alpha > 0$) who chose a larger number in Q3 than in Q4 as being naïfs, because they tended to procrastinate on jobs in a time-inconsistent manner. The nonhyperbolic respondents ($\alpha \leq 0$) or respondents who choose a weakly smaller number in Q3 than Q4 are identified as being sophisticates. The naïfs account for 60.0% (N = 576) of 960 hyperbolic respondents who used to fail their own plans for doing assignments.

2.2.2. The sign effect

Many behavioral economists have reported that discount rates for losses are lower than those for gains (e.g., Thaler, 1981; Loewenstein, 1988; Fredrick *et al.*, 2002; Benzion *et al*., 1989; Chapman, 1996). This sign effect prompts people to prefer to incur losses immediately rather than delay them, and to have a strong desire to avoid future losses by bearing costs in the present. Indeed, the incidence of the sign effect leads people to consider seriously the future psychological and monetary losses of borrowing, addiction, and ill health.11 We thus hypothesize that a person who exhibits the sign effect is more likely to avoid unhealthy behavior and likely to maintain a healthy status, compared to those who do not exhibit it.

To detect the sign effect, two discount rates for payments and receipts are elicited from the JPTR. Table 3 shows the pay-off tables used to elicit discount rates, arranged in terms of the literature (e.g., Harrison *et al*., 2002). Each table consists of nine intertemporal trade-offs, where the monetary amounts with a front-end delay are commonly set at JPY1 million (around USD12,330.76). From the series of options chosen by respondents, which are expected to change from "A" to "B" in Q5 (from "B" to "A" in Q6), the individual discount rate ρ (Q5) (ρ (Q6)) can be estimated as the median interest rates of indifference categories, in which selected options change from "A" to "B" in Q5 (from "B" to "A" in Q6).

The sample mean of ρ (Q5) is 8.8%, whereas that of ρ (Q6) is 1.0%. Since the difference of the two means is highly significant ($p < 0.000$), the average respondent displays the sign effect. Respondents exhibiting the sign effect (N = 1,859) comprise 81.1% of the total. We construct a binary indicator for the sign effect:

$$\text{Sign effect} = \begin{cases} 1 & \text{if } \rho(\text{Q5}) - \rho(\text{Q6}) \geq \text{E}[\rho(\text{Q5}) - \rho(\text{Q6})] + \sigma[\rho(\text{Q5}) - \rho(\text{Q6})] \\ 0 & \text{otherwise} \end{cases},$$

where E(•) and σ(•) represent sample means and standard deviations, respectively.[12]

[11] The predicted relationships between the incidence of the sign effect and actual behavior such as borrowing, cigarette consumption, and BMI are detected in the studies of Ikeda and Kang (2011), Ikeda *et al*. (2010), and Kang and Ikeda (2010), respectively.

[12] We also define an indicator variable for the sign effect, which takes the value of 1 if ρ (Q5) is greater than ρ (Q6), and 0 otherwise. However, the detected associations between the indicator and health-related attributes are found in our estimations to be insignificant.

Insert Table 3

2.2.4. Impatience

In equation (2), the discount rate equals $\alpha\eta$ when $\tau = 0$, which implies that, for any given α, η determines the discount rate for an infinitesimally short horizon. For given α and τ, therefore, the discount rate ρ has the same information as η. To ease interpretation, and considering the data availability, we focus on (α, ρ), instead of (α, η), as determinants of health behavior. The discount factor depends negatively on both declining impatience α and impatience ρ.[13]

To measure the respondents' degree of impatience ρ, we take the standardized average of the four discount rates: Two are discount rates for $\tau = 7$ and 372, elicited from Q1 and Q2, respectively—that is, they are calculated from equation (2); the other two are the discount rates for future receipts and payments, implied by Q5 and Q6.[14]

3. Results

3.1. Means in stratified sample

In the first step of our analysis, we examine simple associations between time discounting and health-related attributes. Table 4 compares the average values of health-related indicators among respondents stratified by whether their impatience is declining ($\alpha > 0$) or not ($\alpha \leq 0$); whether impatience ρ is higher than the average or not; and whether the sign effect is present ($\theta = 1$) or not ($\theta = 0$). The table shows that health-related attributes relate to the degree of declining impatience and the degree of

[13] When we rewrite $f(\tau; \alpha, \eta)$ as $F(\tau, \alpha, \rho(\tau; \alpha, \eta))$, the discount factor F satisfies $\partial F(\tau, \alpha, \rho) / \partial \tau = f_\tau < 0$, $\partial F(\tau, \alpha, \rho) / \partial \alpha = f_\alpha < 0$, and $\partial F(\tau, \alpha, \rho) / \partial \rho = ((1 + \alpha\tau) / \alpha) f_\eta < 0$.

[14] Note that daily discount rates are imputed from Q1 and Q2, whereas ρ (Q5) and ρ (Q6) are expressed in annual rates. This difference does not matter, since the average of the four discount rates is calculated from their standardized values.

impatience, as we hypothesize. First, nonhyperbolic discounters ($\alpha \leq 0$) are more likely to develop healthy behavior and a good health condition than hyperbolic discounters ($\alpha > 0$). For example, respondents who maintain healthy teeth comprise 71.3% of nonhyperbolic discounters—a percentage higher than the corresponding percentages in the samples of naïve hyperbolic discounters (56.1%) and sophisticated hyperbolic discounters (60.4%).[15] Second, naïfs with a positive α value are more likely to develop unhealthy behavior and an ill-health condition than sophisticated hyperbolic respondents and nonhyperbolic respondents. For example, the smoking rate in the sample of naïfs is 22.5%, which is higher than the 16.4% figure for the sample of sophisticates and 14.7% for the nonhyperbolic. Third, in all cases, impatient respondents (ρ > mean) display stronger inclinations toward ill health than patient ones; the differences are all significant and with predicted signs. In contrast, associations with the sign effect are insignificant and unstable, where the observed signs are, in many cases, the opposite of those predicted.

Insert Table 4

3.2. Regression results

To detect associations of time discounting with health-related attributes, we estimate the following probit models:

$$\Pr(Y_i = 1 \mid \alpha_i, \rho_i, \theta_i, x_i) = \begin{cases} \Phi(c + \beta_\alpha \alpha_i + \beta_\rho \rho_i + \beta_\theta \theta_i + \gamma x_i) & \text{for model (A),} \\ \Phi(c + \beta_\alpha \alpha_i + \beta_N \alpha_i * D_{Ni} + \beta_\rho \rho_i + \beta_\theta \theta_i + \gamma x_i) & \text{for model (B),} \end{cases}$$

where, for the dependent variable Y_i, various health-related indicators, as defined in Section 2.1, are adopted; Φ represents the cumulative normal distribution; and (α_i, ρ_i, θ_i) indicate time-discounting attributes: degree of declining impatience, impatience, and the incidence of the sign effect, respectively. In model (B), by adding the interaction term of declining impatience with a naïve indicator, $\alpha_i * D_{Ni}$, a coefficient β_α captures the partial correlation of present-biased preferences for the sophisticates on the

[15] Note that the unreported difference of average values of HEALTH between hyperbolic discounters and nonhyperbolic discounters is significant and with the expected sign, although the difference between the naïve hyperbolic discounters and the sophisticated ones is found to be insignificant.

latent variable of Y_i, and the corresponding partial correlation for the naïfs is obtained by $\beta_\alpha + \beta_N$. The control variables x_i contain the following personal attributes: (i) the degree of risk aversion; (ii) demographic factors including age, gender, and college graduation; and (iii) economic factors including household income, household real asset holdings, and household financial asset holdings.

Table 5 summarizes the marginal effects of declining impatience (α), impatience (ρ), and the sign effect (θ) on the probabilities that health-related indicators will take the value of 1. Corresponding robust standard errors are given in parentheses.

As we shall explain, our hypotheses are supported in the case of impatience and declining impatience. First, health-related attributes have significant associations with the degree of impatience, with the predicted signs. In particular, smoking and teeth condition for males and health condition for females show strongly significant associations with the degree of impatience: all other personal attributes being equal, a 1σ increase in impatience from the average induces a 7.9–9.9 percentage-point increase in the probability of being a smoker and a 6.3–12.3 percentage-point increase in the probability of having unhealthy teeth, for males; similarly, a 1σ increase in impatience induces a 4.9–6.4 percentage-point increase in the probability of developing ill-health condition, for females.

Second, health-related attributes also show significant associations with the degree of declining impatience: when the degree of declining impatience α is larger, the probabilities of males being smokers and being obese and those of females being severely obese and developing ill conditions for both health and teeth are higher. Importantly, health-related attributes associate significantly with the interaction terms of the declining impatience with the naivety indicator, whereas the associations with the interaction terms with the sophistication indicator are insignificant in almost all the cases. This implies that naivety is likely to lead respondents with steeply declining impatience toward more unhealthy behavior, whereas sophistication attenuates such time-inconsistent behavior. Quantitatively, for example, an increase in α by one unit of the sample standard deviation in the naïve sample leads to a 4.4 percentage-point (=0.066*0.672) higher probability of males being obese and a 0.7 percentage-point (=0.051*0.137) higher probability of females being severely obese.[16]

Third, the sign effect shows the predicted signs; however, the significance levels are low.

[16] Among the naïfs, the value of the standard deviation of α is 0.066 for males and 0.051 for females.

Insert Tables 5 (a), (b), and (c)

The principal component measure of health-related attributes

To extract the inclination toward healthy behavior, a principal component variable HEALTHRELATED is created from the binary indicator OBESITY and three ordered variables that take the option number of responses to health-related questions regarding smoking (FQ1), health status (FQ3), and teeth condition (FQ4).[17] The ordinary least squares estimation results using HEALTHRELATED for a regressand are summarized in Table 6: consistent with our expectations, the degree of impatience and the degree of declining impatience each displays strongly significant associations with the health-related principal component measure; also, the sign effect also shows the predicted signs, even though the detected impacts are insignificant.[18]

Insert Table 6

4. Conclusion

[17] To capture consistently tendencies toward healthy statuses, the binary indicator OBESITY and the six-scale ordered variable for smoking (Q1) are re-constructed such that their larger values imply healthier statuses.

[18] Although the estimation of the generalized hyperbolic discounting function enables us to detect the marginal effect of a parametric increase in the degree of declining impatience on health-related behavior, the results may depend on the specification of the discounting function. To focus on the impact of the incidence of present-bias properties without depending on the specification of functional form, instead of α_i, we use as a regressor the present-biased binary indicator, which takes the value of 1 if the respondent is present-biased ($\alpha_i > 0$), and 0 otherwise. See Appendices (a), (b), (c), and (d) for the estimation results, which indicate that the same detected relationships in Section 3 hold in the case of the present-bias indicator.

Based on analyses of data from an original Internet survey, we have shown that personal health-related attributes have expected correlations with time-discounting properties, including impatience, the present bias, and the sign effect: impatient respondents are more likely to have inclinations toward unhealthy behavior; respondents with more steeply declining impatience tend to develop more unhealthy behavior, where the tendencies are stronger for naïfs than for sophisticates; and the sign effect shows associations with health-related attributes, although the significance levels are not overly high.

Our research is novel in three respects. First, the parameterized time-discounting properties induced by the generalized hyperbolic discounting function enable us to detect the empirical associations between the degree of declining impatience and health-related behavior. Second, hyperbolic discounters are classified into naïfs and sophisticates, based on the self-reported gap between planning and actual behavior for an onerous assignment. Third, partial associations between health-related attributes and each of the three time-discounting properties are detected.

References

Ainslie, G., 1992, Picoeconomics, Cambridge, UK: Cambridge University Press.

Ainslie, G., 2001, Breakdown of Will, Cambridge, UK: Cambridge University Press.

Baker, F., M. W. Johnson, and W. K. Bickel, 2003, Delay discounting in current and never-before cigarette smokers: Similarities and differences across commodity, sign, and magnitude, Journal of Abnormal Psychology, 112, 382-92.

Benzion, U., A. Rapoport, and J. Yagil, 1989, Discount rates inferred from decisions: an experimental study, Management Science, 35, 270-284.

Bickel, W. K., A.L. Odum, and G. J. Madden, 1999, Impulsivity and cigarette smoking: delay discounting in current never, and ex-smokers, Psychopharmacology, 146, 447-454.

Blondel, S., Y. Lohéac, and S. Rinaudo, 2007, Rationality and drug use: An experimental approach, Journal of Health Economics, 26, 643-658.

Cawley, J., and C. J. Ruhm, 2011, The economics of risky health behaviors, in *Handbook of Health Economics, Vol.2*, edited by M. Pauly, T. McGuire, and P. Barros, Elsevier.

Chabris, C. F., D. Laibson, C. L. Morris, J. P. Schuldt, and D. Taubinsky, 2008, Individual laboratory-measured discount rates predicted field behavior, Journal of Risk and Uncertainty, 37, 237-269.

Chapman, G., 1996, Temporal discounting and utility for health and money, Journal of Experimental Psychology: Learning, Memory, and Cognition, 22, 771-791.

Chapman, G., 2003, Time discounting of health outcomes, In *Time and Decision*, edited by G. Loewenstein, D. Read, and F. Baumeister, New York, US: Lussell Sage Foundation.

Frederick, S.G., G. Loewenstein, and T. O'Donoghue, 2002, Time discounting and time preference: A critical review, Journal of Economic Literature 40, 351-401.

Fuchs, V. R., 1980, Time preference and health: An exploratory study, NBER Working Paper 539.

Grossman, M., 1972, On the concept of health capital and the demand for health, Journal of Political Economy 80, 223-255.

Grignon, M.., 2009, An empirical investigation of heterogeneity in time preferences and smoking behaviors , Journal of Socio-Economics, 38, 739-751.

Gruber, J., and B. Kőszegi, 2001, Is addiction “rational”?: Theory and evidence, Quarterly Journal of Economics, 116, 1261-1303.

Gruber, J., and B. Kőszegi, 2004, Tax incidence when individuals are time-inconsistent: The case of cigarette excise taxes, Journal of Public Economics, 88, 1959-1987.

Harrison, G.W., M.I. Lau, and M.B. Williams, 2002, Estimating individual discount rates in Denmark: A field experiment, American Economic Review, 92, 1606-1617.

Heidhue, P. and B. Kőszegi, 2010, Exploiting naïvete about self-control in the credit market, American Economic Review 100, 2279-2303.

Ida, T., and R. Goto, 2009, Simultaneous measurement of time and risk preferences: stated preference discrete choice modeling analysis depending on smoking behavior, International Economic Review 50, 1169-1182.

Ikeda, S., and M. Kang, 2011, Generalized hyperbolic discounting, borrowing aversion, and debt holding, ISER Discussion Paper, 817.

Ikeda, S., M. Kang, and F. Ohtake, 2010, Hyperbolic discounting, the sign effect, and the body mass index, Journal of Health Economics, 29, 268-284.

Kang, M., and S. Ikeda, 2010, Time discounting and smoking behavior under tax hike, ISER Discussion Paper, 782.

Kilby, K.N., N. M. Petry, and W. K. Warren, 1999, Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls, Journal of Experimental Psychology, 128, 78-87.

Loewenstein, G., 1988, Frames of mind in intetertemporal choice, Management Science, 34, 200-214.

Loewenstein, G., and D. Prelec, 1992, Anomalies intertemporal choice: Evidence and an interpretation, Quarterly Journal of Economics, 107, 573-597.

Madden, G. J., N. M. Petry, G. J. Barger, and W. K. Bickel, 1997, Impulsive and self-control choices in opioid-dependent patients and non-drug-using control patients: Drug and monetary rewards, Experimental and Clinical Psychopharmacology, 5, 256-262.

Madden, G. J., W. K. Bickel, and E. A. Eric, 1999, Discounting of delayed rewards in opioid-dependent outpatients: Exponential or hyperbolic discounting functions?, Experimental and Clinical Psychopharmacology, 7, 284-293.

Mitchell, S. H., 1999, Measures of impulsivity in cigarette smokers and non-smokers,

Psychopharmacology, 146, 455-464.

O'Donoghue, T. and M. Rabin, 1999, Doing it or later, American Economic Review 89, 103-125.

Odum, A. L., G. J. Madden, and W. K. Bickel, 2002, Discounting of delayed health gains and losses by current, never- and ex-smokers of cigarettes, Nicotine and Tobacco Research, 4, 295-303.

Ohmura, Y., T. Takahashi, and N. Kitamura, 2005, Discounting delayed and probabilistic monetary gains and losses by smokers of cigarettes, Psychopharmacology, 182, 508-515.

Reynolds, B., K. Karraker, K. Horn, and J. B. Richards, 2004, Delay and probability discounting as related to different stages of adolescent smoking and non-smoking, Behavioural Processes, 64, 333-344.

Thaler, R., 1981, Some empirical evidence on dynamic inconsistency, Economics Letters, 8, 201-207.

The Examination Committee of Criteria for ‘Obesity Disease’ in Japan, chaired by Y. Matsuzawa, Japan Society for the Study of Obesity, 2002. New criteria for obesity disease’ in Japan, Circulation Journal 66, 987–992.

Table 1
Summary statistics

Panel A. Background attributes	Mean	(S.D.)
	N	
Age	41.763	(12.46)
	2386	
Male	0.499	(0.50)
	2386	
University grad.	0.546	(0.50)
	2386	
Risk aversion	0.623	(0.31)
	2386	
Household income (in JPY million)	6.90	(4.09)
	2361	
Household's financial assets (in JPY million)	14.53	(23.67)
	2345	
Household's real assets (in JPY million)	21.15	(29.54)
	2351	
Panel B. Health-related attributes		
SMOKING	0.172	(0.38)
	1886	
HEALTH	0.726	(0.45)
	2386	
TEETH	0.652	(0.48)
	2386	
OBESITY	0.181	(0.38)
	2351	
SEVERE OBESITY	0.031	(0.17)
	2351	
UNDERWEIGHT	0.115	(0.32)
	2351	

Note: Data source: The original internet survey, The Japan Internet Survey on Preferences Relating To Time and Risk (JPTR).

Table 2: Questions regarding health-related attributes

FQ1. How many cigarettes do you smoke regularly? Select a proximal option from the following:

(i) Never smoke

(ii) Hardly smoke

(iii) Smoke sometimes

(iv) About 10 cigarettes per day

(v) About a pack per day

(vi) More than two packs per day

(vii) I used to smoke, but have quit

FQ2. What is your height and weight?

FQ3. How is your health? Using a scale of 1 to 10—where 10 is “good” and 1 is “bad”—choose a number that describes your present situation.

(Good) (Bad)

10 9 8 7 6 5 4 3 2 1

FQ4. To which level does your dentition status belong?

(i) All permanent teeth (including treated teeth)

(ii) Some missing teeth, but replaced by dental implant or partial denture

(iii) More than one missing tooth, without any dental treatment

(iv) Wearing a full set of dentures

Table 3: Questions to elicit discount rates (Q5 and Q6)

Q5. Suppose you have two options to receive some money. You may choose Option "A", to receive 10,000,000 JPY today; or Option "B", to receive a different amount in a year. Compare the amounts and timing in Option "A" with Option "B" and indicate which amount you would prefer to receive for each of all 9 choices.

Option A (Receipt today)	Option B (Receipt in a year)
JPY 1,000,000 (USD 12,330.76)	JPY 1,000,000 (USD 12,330.76)
JPY 1,000,000 (USD 12,330.76)	JPY 1,001,000 (USD 12,343.09)
JPY 1,000,000 (USD 12,330.76)	JPY 1,005,000 (USD 12,392.41)
JPY 1,000,000 (USD 12,330.76)	JPY 1,010,000 (USD 12,454.07)
JPY 1,000,000 (USD 12,330.76)	JPY 1,020,000 (USD 12,577.38)
JPY 1,000,000 (USD 12,330.76)	JPY 1,060,000 (USD 13,070.61)
JPY 1,000,000 (USD 12,330.76)	JPY 1,100,000 (USD 13,563.84)
JPY 1,000,000 (USD 12,330.76)	JPY 1,300,000 (USD 16,029.99)
JPY 1,000,000 (USD 12,330.76)	JPY 1,600,000 (USD 19,729.22)

Q6. Suppose you have two options to pay some money. You may choose Option "A", to pay 1,000,000 JPY today; or Option "B", to pay a different amount in a year. Compare the amounts and timing in Option "A" with Option "B" and indicate which amount you would prefer to pay for each of all 9 choices.

Option A (Pay today)	Option B (Pay in a year)
JPY 1,000,000 (USD 12,330.76)	JPY 920,000 (USD 11,344.30)
JPY 1,000,000 (USD 12,330.76)	JPY 970,000 (USD 11,960.84)
JPY 1,000,000 (USD 12,330.76)	JPY 1,000,000 (USD 12,330.76)
JPY 1,000,000 (USD 12,330.76)	JPY 1,001,000 (USD 12,343.09)
JPY 1,000,000 (USD 12,330.76)	JPY 1,005,000 (USD 12,392.41)
JPY 1,000,000 (USD 12,330.76)	JPY 1,010,000 (USD 12,454.07)
JPY 1,000,000 (USD 12,330.76)	JPY 1,050,000 (USD 13,947.30)
JPY 1,000,000 (USD 12,330.76)	JPY 1,100,000 (USD 13,563.84)
JPY 1,000,000 (USD 12,330.76)	JPY 1,300,000 (USD 16,029.99)

Note: The US dollar amounts are computed by using the average JPY/ USD exchange rate, 81.098, in October 21 to 27, 2010.

Table 4

Summary statistics stratified by time discounting variables

	Declining impatience (α)				Impatience (ρ)			Sign effects (θ)		
	α>0		α≦0	χ^2 test	ρ>mean	ρ≦mean	χ^2 test	θ=1	θ=0	χ^2 test
	Naif	Sophisticate								
	Mean (S.D.) N	Mean (S.D.) N	Mean (S.D.) N	χ^2 statistics (P-value)	Mean (S.D.) N	Mean (S.D.) N	χ^2 statistics (P-value)	Mean (S.D.) N	Mean (S.D.) N	χ^2 statistics (P-value)
Panel A. Background attributes										
Age	45.68 (12.44) 576	44.1 (12.65) 384	39.26 (11.87) 1317	**198.84** (0.00)	45.23 (12.34) 697	40.3 (12.19) 1584	**119.69** (0.00)	46.376 (12.16) 181	41.410 (12.39) 2100	**61.61** (0.05)
Male	0.516 (0.50) 576	0.521 (0.50) 384	0.472 (0.50) 1317	**4.61** (0.10)	0.575 (0.49) 697	0.462 (0.50) 1584	**24.81** (0.00)	0.6022 (0.49) 181	0.488 (0.50) 2100	**4.61** (0.10)
University grad.	0.535 (0.50) 576	0.534 (0.50) 384	0.557 (0.50) 1317	1.10 (0.58)	0.505 (0.50) 697	0.563 (0.50) 1584	**6.59** (0.01)	0.4199 (0.49) 181	0.556 (0.50) 2100	1.10 (0.58)
Risk aversion	0.636 (0.27) 576	0.583 (0.34) 384	0.628 (0.32) 1317	**47.90** (0.00)	0.629 (0.32) 699	0.623 (0.30) 1582	**21.12** (0.00)	0.659 (0.34) 181	0.622 (0.30) 2100	**66.51** (0.00)
Household income (in JPY million)	7.00 (4.32) 565	7.26 (4.11) 381	6.75 (3.97) 1307	29.59 (0.13)	6.7082 (4.16) 687	7.01 (4.07) 1570	**18.27** (0.08)	6.0866 (4.29) 179	6.989 (4.08) 2078	29.59 (0.13)
Household's financial assets (in JPY million)	13.08 (22.17) 560	16.22 (23.03) 380	14.86 (24.62) 1298	**29.64** (0.04)	13.994 (24.76) 681	15.04 (23.46) 1560	**32.65** (0.00)	14.174 (29.57) 174	14.768 (23.32) 2067	**29.64** (0.04)
Household's real assets (in JPY million)	22.46 (28.98) 562	24.93 (31.57) 382	19.52 (29.31) 1299	**36.13** (0.01)	21.407 (30.64) 686	21.46 (29.60) 1562	13.51 (0.14)	19.134 (31.85) 176	21.640 (29.74) 2072	**36.13** (0.01)
Panel B. Health-related attributes										
SMOKING	0.225 (0.42) 427	0.164 (0.37) 304	0.147 (0.35) 1070	**13.34** (0.00)	0.249 (0.43) 538	0.139 (0.35) 1264	**31.96** (0.00)	0.241 (0.43) 141	0.166 (0.37) 1661	**5.13** (0.02)
HEALTH	0.698 (0.46) 576	0.729 (0.44) 384	0.744 (0.44) 1317	4.34 (0.11)	0.692 (0.46) 699	0.746 (0.44) 1582	**7.03** (0.01)	0.724 (0.45) 181	0.730 (0.44) 2100	0.03 (0.86)
TEETH	0.561 (0.50) 576	0.604 (0.49) 384	0.713 (0.45) 1317	**46.68** (0.00)	0.567 (0.50) 699	0.695 (0.46) 1582	**35.63** (0.00)	0.552 (0.50) 181	0.665 (0.47) 2100	**9.31** (0.00)
OBESITY	0.224 (0.42) 571	0.203 (0.40) 379	0.151 (0.36) 1295	**16.19** (0.00)	0.236 (0.43) 686	0.159 (0.37) 1565	**18.97** (0.00)	0.261 (0.44) 176	0.176 (0.38) 2075	**7.94** (0.00)
SEVERE OBESITY	0.040 (0.20) 571	0.029 (0.17) 379	0.026 (0.16) 1295	2.68 (0.26)	0.048 (0.21) 686	0.024 (0.15) 1565	**9.47** (0.00)	0.040 (0.20) 176	0.030 (0.17) 2075	0.48 (0.49)
UNDERWEIGHT	0.088 (0.28) 571	0.121 (0.33) 379	0.127 (0.33) 1295	**6.05** (0.05)	0.086 (0.28) 686	0.128 (0.33) 1565	**8.40** (0.00)	0.085 (0.28) 176	0.118 (0.32) 2075	**6.05** (0.05)

Note: Bold digits for χ^2 statistics represent the significance at the 10 % level.

Table 5 (a)
The marginal effects of time discounting on health-related attributes (all samples)

	Model	Declining impatience(α)		Impatience (ρ)	Sign effect (θ)	Log pseudolikelihood	#obs	Controlled
SMOKING	(A)	0.597 ***		0.080 ***	-0.061 *	-806.84746	1802	-
		(0.18)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.721 ***	0.538 **	0.077 ***	-0.053	-758.09744	1719	-
		(0.23)	(0.27)	(0.02)	(0.03)			
	(A)	0.308 *		0.051 ***	-0.064 **	-702.12556	1761	○
		(0.16)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.426 **	0.200	0.050 ***	-0.054 *	-661.11236	1680	○
		(0.22)	(0.25)	(0.02)	(0.03)			
HEALTH	(A)	-0.429 **		-0.039 **	0.062	-1326.3904	2281	-
		(0.20)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.900 ***	0.423	-0.028	0.047	-1252.4261	2174	-
		(0.26)	(0.34)	(0.02)	(0.04)			
	(A)	-0.335 *		-0.029	0.073 *	-1280.2232	2235	○
		(0.20)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.720 ***	0.423	-0.019	0.065	-1207.7426	2130	○
		(0.26)	(0.35)	(0.02)	(0.04)			
TEETH	(A)	-0.704 ***		-0.101 ***	0.061	-1443.9128	2281	-
		(0.21)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-1.008 ***	-0.620 *	-0.104 ***	0.072	-1367.1431	2174	-
		(0.29)	(0.34)	(0.02)	(0.05)			
	(A)	-0.255		-0.042 **	0.061	-1192.1658	2235	○
		(0.22)		(0.02)	(0.05)			
		Naifs	Sophisticates					
	(B)	-0.473	-0.161	-0.047 **	0.077 *	-1134.1001	2130	○
		(0.29)	(0.37)	(0.02)	(0.04)			
OBESITY	(A)	0.615 ***		0.026 *	0.022	-1057.4625	2251	-
		(0.16)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	0.717 ***	0.387	0.028 *	0.011	-1003.4382	2147	-
		(0.21)	(0.27)	(0.02)	(0.04)			
	(A)	0.386 **		-0.004	0.029	-960.21508	2212	○
		(0.16)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	0.463 **	0.193	-0.001	0.014	-907.93997	2109	○
		(0.20)	(0.26)	(0.02)	(0.04)			
SEVERE OBESITY	(A)	0.143 **		0.013 **	-0.014	-306.90501	2251	-
		(0.06)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.163 **	0.053	0.014 **	-0.019 **	-290.18041	2147	-
		(0.08)	(0.12)	(0.01)	(0.01)			
	(A)	0.117 **		0.010 *	-0.013	-289.47664	2212	○
		(0.06)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.130 *	0.037	0.011 *	-0.018 ***	-271.87256	2109	○
		(0.07)	(0.10)	(0.01)	(0.01)			
UNDERWEIGHT	(A)	-0.244		-0.032 **	0.019	-800.59426	2251	-
		(0.18)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.110	-0.652 **	-0.032 **	0.017	-768.81153	2147	-
		(0.22)	(0.27)	(0.02)	(0.04)			
	(A)	-0.009		-0.005	0.014	-707.19834	2212	○
		(0.14)		(0.01)	(0.04)			
		Naifs	Sophisticates					
	(B)	0.097	-0.271	-0.005	0.014	-679.30904	2109	○
		(0.18)	(0.22)	(0.01)	(0.04)			

Notes : The estimated marginal effects are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

Table 5 (b)
The marginal effects of time discounting on health-related attributes (male samples)

	Model	Declining impatience（α）		Impatience (ρ)	Sign effect (θ)	Log pseudolikelihood	#obs	Controlled
SMOKING	(A)	0.929 ***		0.099 ***	-0.089	-474.06317	832	-
		(0.31)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.995 **	1.086 **	0.097 ***	-0.074	-440.93851	782	-
		(0.40)	(0.51)	(0.03)	(0.06)			
	(A)	0.754 **		0.080 ***	-0.102 *	-430.84857	815	○
		(0.32)		(0.03)	(0.05)			
		Naifs	Sophisticates					
	(B)	0.717 *	0.880 *	0.079 ***	-0.086	-403.38312	767	○
		(0.41)	(0.50)	(0.03)	(0.06)			
HEALTH	(A)	-0.371		-0.014	0.067	-681.02099	1133	-
		(0.26)		(0.03)	(0.05)			
		Naifs	Sophisticates					
	(B)	-0.813 **	0.582	0.003	0.043	-631.9054	1063	-
		(0.34)	(0.46)	(0.03)	(0.06)			
	(A)	-0.259		-0.004	0.080	-653.65254	1112	○
		(0.27)		(0.03)	(0.05)			
		Naifs	Sophisticates					
	(B)	-0.606 *	0.618	0.011	0.066	-604.7578	1044	○
		(0.35)	(0.47)	(0.03)	(0.06)			
TEETH	(A)	-0.422		-0.116 ***	0.031	-734.44813	1133	-
		(0.28)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.929 **	-0.314	-0.123 ***	0.043	-681.99229	1063	-
		(0.38)	(0.45)	(0.03)	(0.06)			
	(A)	-0.146		-0.063 **	0.031	-621.86298	1112	○
		(0.29)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.492	-0.077	-0.071 **	0.047	-581.56499	1044	○
		(0.38)	(0.46)	(0.03)	(0.07)			
OBESITY	(A)	0.672 ***		0.015	-0.005	-654.6877	1127	-
		(0.25)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.879 ***	0.331	0.019	-0.028	-613.12904	1058	-
		(0.32)	(0.42)	(0.02)	(0.06)			
	(A)	0.550 **		-0.005	-0.004	-625.37227	1107	○
		(0.25)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.670 **	0.280	0.000	-0.036	-583.5051	1039	○
		(0.33)	(0.42)	(0.03)	(0.06)			
SEVERE OBESITY	(A)	0.120		0.016	-0.021	-205.88428	1127	-
		(0.11)		(0.01)	(0.02)			
		Naifs	Sophisticates					
	(B)	0.109	0.015	0.018 *	-0.034 **	-193.36867	1058	-
		(0.14)	(0.22)	(0.01)	(0.01)			
	(A)	0.128		0.015 *	-0.023 *	-195.35226	1107	○
		(0.10)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.111	0.028	0.017 **	-0.034 ***	-181.94022	1039	○
		(0.13)	(0.20)	(0.01)	(0.01)			
UNDERWEIGHT	(A)	-0.108		-0.013	0.054	-206.15507	1127	-
		(0.13)		(0.01)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.124	-0.046	-0.013	0.061	-196.8572	1058	-
		(0.20)	(0.14)	(0.01)	(0.05)			
	(A)	-0.016		-0.005	0.049	-180.894	1107	○
		(0.09)		(0.01)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.009	0.033	-0.004	0.055	-170.55379	1039	○
		(0.13)	(0.11)	(0.01)	(0.04)			

Notes: The estimated marginal effects are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

Table 5 (c)
The marginal effects of time discounting on health-related attributes (female samples)

	Model	Declining impatience(α)		Impatience (ρ)	Sign effect (θ)	Log pseudolikelihood	#obs	Controlled
SMOKING	(A)	0.115		0.043 **	-0.039	-282.34039	970	-
		(0.20)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.280	-0.076	0.041 **	-0.033	-269.72196	937	-
		(0.26)	(0.37)	(0.02)	(0.04)			
	(A)	-0.102		0.026	-0.033	-264.28625	946	○
		(0.19)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.162	-1.011	0.024	-0.029	-249.38788	913	○
		(0.23)	(0.64)	(0.02)	(0.03)			
HEALTH	(A)	-0.501		-0.064 **	0.055	-641.75385	1148	-
		(0.31)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-1.034 **	0.264	-0.059 **	0.053	-616.57141	1111	-
		(0.41)	(0.52)	(0.03)	(0.06)			
	(A)	-0.518 *		-0.054 *	0.059	-617.29984	1123	○
		(0.31)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.969 **	0.132	-0.049 *	0.063	-594.0888	1086	○
		(0.42)	(0.54)	(0.03)	(0.06)			
TEETH	(A)	-1.054 ***		-0.074 **	0.098	-703.82783	1148	-
		(0.35)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-1.054 **	-0.969 *	-0.075 **	0.103	-680.51742	1111	-
		(0.47)	(0.54)	(0.03)	(0.06)			
	(A)	-0.437		-0.008	0.076	-562.013	1123	○
		(0.37)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.482	-0.299	-0.014	0.092	-545.26143	1086	○
		(0.45)	(0.65)	(0.03)	(0.06)			
OBESITY	(A)	0.289		0.005	0.085	-344.54865	1124	-
		(0.19)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.311	0.236	0.005	0.090	-334.11273	1089	-
		(0.25)	(0.29)	(0.02)	(0.06)			
	(A)	0.224		-0.004	0.078	-330.83656	1105	○
		(0.19)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.255	0.129	-0.004	0.081	-319.81597	1070	○
		(0.24)	(0.30)	(0.02)	(0.06)			
SEVERE OBESITY	(A)	0.136 **		0.005	-0.003	-93.731278	1124	-
		(0.06)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.165 **	0.065	0.005	-0.004	-88.6025	1089	-
		(0.08)	(0.08)	(0.01)	(0.01)			
	(A)	0.112 **		0.004	-0.003	-91.245502	1105	○
		(0.06)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.137 **	0.054	0.004	-0.004	-86.222431	1070	○
		(0.07)	(0.07)	(0.01)	(0.01)			
UNDERWEIGHT	(A)	-0.131		-0.025	-0.039	-538.04786	1124	-
		(0.34)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.134	-1.239 **	-0.026	-0.052	-518.41132	1089	-
		(0.42)	(0.60)	(0.03)	(0.06)			
	(A)	-0.005		-0.006	-0.054	-515.49627	1105	○
		(0.32)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.252	-1.025 *	-0.007	-0.064	-496.29253	1070	○
		(0.39)	(0.57)	(0.03)	(0.06)			

Notes: The estimated marginal effects are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

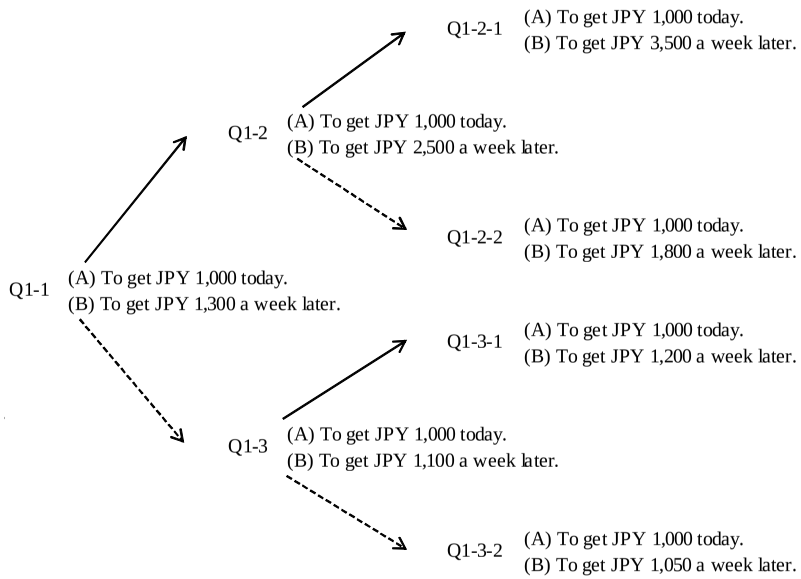
Table 6
The marginal effects of time discounting on the health-related principal component

		Model	Declining impatience（α）		Impatience (ρ)	Sign effect (θ)	R-squared	#obs	Controlled
HEALTHRELATED	All	(A)	-3.065 ***		-0.329 ***	0.061	0.046	1773	-
			(0.69)		(0.06)	(0.16)			
			Naifs	Sophisticates					
		(B)	-4.137 ***	-1.778	-0.320 ***	0.066	0.0485	1693	-
			(0.86)	(1.11)	(0.06)	(0.16)			
		(A)	-1.856 ***		-0.158 ***	0.111	0.2421	1739	○
			(0.65)		(0.06)	(0.14)			
			Naifs	Sophisticates					
		(B)	-2.694 ***	-0.754	-0.155 ***	0.129	0.2404	1660	○
			(0.81)	(1.07)	(0.06)	(0.15)			
	Male	(A)	-3.188 ***		-0.304 ***	0.030	0.0423	826	-
			(0.90)		(0.08)	(0.21)			
			Naifs	Sophisticates					
		(B)	-4.146 ***	-2.417	-0.296 ***	0.043	0.0446	777	-
			(1.16)	(1.47)	(0.09)	(0.22)			
		(A)	-2.332 **		-0.157 *	0.125	0.2331	810	○
			(0.91)		(0.08)	(0.19)			
			Naifs	Sophisticates					
		(B)	-2.612 **	-1.885	-0.150 *	0.137	0.2302	762	○
			(1.23)	(1.53)	(0.08)	(0.20)			
	Female	(A)	-2.014 **		-0.279 ***	0.131	0.0323	947	-
			(0.88)		(0.08)	(0.21)			
			Naifs	Sophisticates					
		(B)	-3.357 ***	-0.435	-0.274 ***	0.127	0.0374	916	-
			(1.06)	(1.23)	(0.08)	(0.22)			
		(A)	-1.202		-0.151 **	0.104	0.1584	929	○
			(0.87)		(0.07)	(0.20)			
			Naifs	Sophisticates					
		(B)	-2.627 ***	0.462	-0.157 **	0.132	0.1607	898	○
			(0.99)	(1.28)	(0.08)	(0.21)			

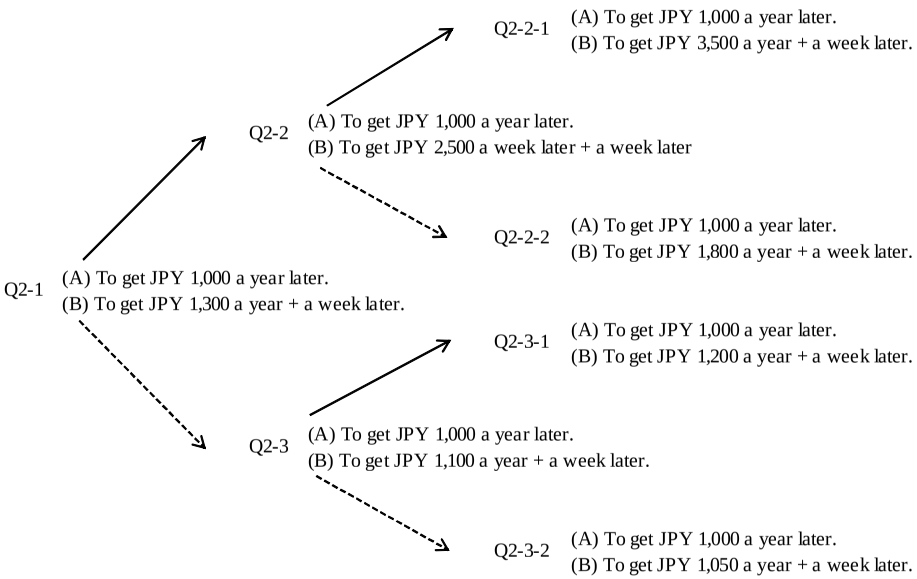
Notes: The estimated coefficients are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

Figure 1: Questions Q1 and Q2 to elicit the generalized hyperbolic discount factor

Q1 (Questions on discount rates for immediate future)
Which one do you prefer? Choos one you prefer.



Q2 (Question on discount rates for distant future 〉
Which one do you prefer? Choos one you prefer.



Appendix (a)

The marginal effects on health-related attributes: Estimation with the present bias dummy (all samples)

	Model	Present bias (α>0) = 1		Impatience (ρ)	Sign effect (θ)	Log pseudolikelihood	#obs	Controlled
SMOKING	(A)	0.056 ***		0.080 ***	-0.052	-807.18862	1802	-
		(0.02)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.070 ***	0.023	0.078 ***	-0.043	-702.47076	1761	-
		(0.02)	(0.03)	(0.02)	(0.04)			
	(A)	0.027		0.052 ***	-0.060 **	-758.87998	1719	○
		(0.02)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.050 **	-0.001	0.051 ***	-0.050 *	-659.9494	1680	○
		(0.02)	(0.02)	(0.02)	(0.03)			
HEALTH	(A)	-0.036 *		-0.040 **	0.055	-1326.9455	2281	-
		(0.02)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.040 *	-0.015	-0.029	0.041	-1280.3665	2235	-
		(0.02)	(0.03)	(0.02)	(0.04)			
	(A)	-0.031		-0.029	0.069 *	-1257.9866	2174	○
		(0.02)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.030	-0.019	-0.020	0.061	-1211.6709	2130	○
		(0.02)	(0.03)	(0.02)	(0.04)			
TEETH	(A)	-0.140 ***		-0.097 ***	0.050	-1425.0716	2281	-
		(0.02)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.156 ***	-0.114 ***	-0.101 ***	0.059	-1189.7081	2235	-
		(0.02)	(0.03)	(0.02)	(0.05)			
	(A)	-0.054 **		-0.042 **	0.057	-1350.8305	2174	○
		(0.02)		(0.02)	(0.05)			
		Naifs	Sophisticates					
	(B)	-0.064 **	-0.037	-0.048 **	0.073	-1132.2764	2130	○
		(0.03)	(0.03)	(0.02)	(0.04)			
OBESITY	(A)	0.060 ***		0.027 *	0.032	-1057.6628	2251	-
		(0.02)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	0.066 ***	0.051 **	0.029 *	0.019	-960.75763	2212	-
		(0.02)	(0.02)	(0.02)	(0.04)			
	(A)	0.036 **		-0.003	0.036	-1003.3039	2147	○
		(0.02)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	0.041 **	0.034	0.000	0.019	-908.07668	2109	○
		(0.02)	(0.02)	(0.02)	(0.04)			
SEVERE OBESITY	(A)	0.007		0.013 **	-0.011	-309.09243	2251	-
		(0.01)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.010	-0.001	0.014 **	-0.018 *	-291.37241	2212	-
		(0.01)	(0.01)	(0.01)	(0.01)			
	(A)	0.006		0.010 *	-0.011	-291.54504	2147	○
		(0.01)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.010	-0.001	0.011 **	-0.017 **	-272.90882	2109	○
		(0.01)	(0.01)	(0.01)	(0.01)			
UNDERWEIGHT	(A)	-0.020		-0.032 **	0.015	-800.55876	2251	-
		(0.01)		(0.02)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.033 **	0.003	-0.033 **	0.017	-707.13943	2212	-
		(0.02)	(0.02)	(0.02)	(0.04)			
	(A)	0.004		-0.006	0.014	-768.43155	2147	○
		(0.01)		(0.01)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.009	0.024	-0.007	0.017	-678.38265	2109	○
		(0.02)	(0.02)	(0.01)	(0.04)			

Notes: The estimated marginal effects are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

Appendix (b)

The marginal effects on health-related attributes: Estimation with the present bias dummy (male samples)

	Model	Present bias (α>0) = 1		Impatience (ρ)	Sign effect (θ)	Log pseudolikelihood	#obs	Controlled
SMOKING	(A)	0.081 ***		0.098 ***	-0.070	-475.27319	832	-
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.109 ***	0.033	0.098 ***	-0.057	-432.82321	815	-
		(0.04)	(0.04)	(0.03)	(0.06)			
	(A)	0.047		0.082 ***	-0.086	-442.13036	782	○
		(0.03)		(0.03)	(0.05)			
		Naifs	Sophisticates					
	(B)	0.085 **	0.003	0.082 ***	-0.072	-403.97121	767	○
		(0.04)	(0.04)	(0.03)	(0.06)			
HEALTH	(A)	-0.024		-0.015	0.060	-681.65579	1133	-
		(0.03)		(0.02)	(0.05)			
		Naifs	Sophisticates					
	(B)	-0.022	-0.010	0.001	0.038	-654.02827	1112	-
		(0.03)	(0.04)	(0.03)	(0.06)			
	(A)	-0.014		-0.005	0.075	-635.68873	1063	○
		(0.03)		(0.03)	(0.05)			
		Naifs	Sophisticates					
	(B)	-0.001	-0.008	0.010	0.063	-607.41528	1044	○
		(0.03)	(0.04)	(0.03)	(0.06)			
TEETH	(A)	-0.137 ***		-0.113 ***	0.025	-724.42396	1133	-
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.164 ***	-0.091 **	-0.121 ***	0.035	-619.84975	1112	-
		(0.03)	(0.04)	(0.03)	(0.06)			
	(A)	-0.065 **		-0.064 **	0.029	-673.81662	1063	○
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.086 **	-0.025	-0.073 **	0.044	-579.7625	1044	○
		(0.04)	(0.04)	(0.03)	(0.07)			
OBESITY	(A)	0.072 ***		0.016	0.007	-654.67041	1127	-
		(0.03)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.096 ***	0.043	0.019	-0.018	-626.13881	1107	-
		(0.03)	(0.04)	(0.02)	(0.06)			
	(A)	0.050 *		-0.002	0.006	-612.344	1058	○
		(0.03)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.069 **	0.033	0.002	-0.028	-583.52025	1039	○
		(0.03)	(0.04)	(0.03)	(0.06)			
SEVERE OBESITY	(A)	0.001		0.016 *	-0.019	-206.55384	1127	-
		(0.01)		(0.01)	(0.02)			
		Naifs	Sophisticates					
	(B)	0.007	-0.009	0.018 *	-0.034 **	-196.20252	1107	-
		(0.01)	(0.02)	(0.01)	(0.01)			
	(A)	0.004		0.016 *	-0.021	-193.322	1058	○
		(0.01)		(0.01)	(0.01)			
		Naifs	Sophisticates					
	(B)	0.010	-0.007	0.018 **	-0.033 ***	-181.91	1039	○
		(0.01)	(0.02)	(0.01)	(0.01)			
UNDERWEIGHT	(A)	-0.012		-0.013	0.051	-205.99189	1127	-
		(0.01)		(0.01)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.037 **	0.014	-0.012	0.065	-180.90419	1107	-
		(0.02)	(0.02)	(0.01)	(0.05)			
	(A)	0.000		-0.005	0.049	-193.21934	1058	○
		(0.01)		(0.01)	(0.04)			
		Naifs	Sophisticates					
	(B)	-0.020	0.018	-0.004	0.062	-167.70486	1039	○
		(0.01)	(0.01)	(0.01)	(0.05)			

Notes: The estimated marginal effects are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

Appendix (c)

The marginal effects on health-related attributes: Estimation with the present bias dummy (female samples)

	Model	Present bias (α>0) = 1		Impatience (ρ)	Sign effect (θ)	Log pseudolikelihood	#obs	Controlled
SMOKING	(A)	0.027		0.043 **	-0.038	-281.41183	970	-
		(0.02)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.035	0.010	0.041 **	-0.033	-264.04591	946	-
		(0.02)	(0.03)	(0.02)	(0.03)			
	(A)	0.015		0.027	-0.034	-268.9623	937	○
		(0.02)		(0.02)	(0.03)			
		Naifs	Sophisticates					
	(B)	0.027	-0.001	0.026	-0.030	-250.39678	913	○
		(0.02)	(0.02)	(0.02)	(0.03)			
HEALTH	(A)	-0.043 *		-0.064 **	0.051	-641.61333	1148	-
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.056 *	-0.015	-0.059 **	0.047	-617.04976	1123	-
		(0.03)	(0.04)	(0.03)	(0.06)			
	(A)	-0.048 *		-0.054 *	0.056	-618.17789	1111	○
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.059 *	-0.025	-0.050 *	0.055	-595.1549	1086	○
		(0.03)	(0.04)	(0.03)	(0.06)			
TEETH	(A)	-0.139 ***		-0.070 **	0.085	-696.14385	1148	-
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.146 ***	-0.137 ***	-0.070 **	0.090	-561.72643	1123	-
		(0.03)	(0.04)	(0.03)	(0.07)			
	(A)	-0.044		-0.009	0.073	-672.06012	1111	○
		(0.03)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.046	-0.049	-0.014	0.089	-544.72731	1086	○
		(0.04)	(0.04)	(0.03)	(0.06)			
OBESITY	(A)	0.032 *		0.004	0.090	-343.89642	1124	-
		(0.02)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.026	0.045 *	0.003	0.096	-330.68714	1105	-
		(0.02)	(0.03)	(0.02)	(0.06)			
	(A)	0.022		-0.004	0.082	-333.06401	1089	○
		(0.02)		(0.02)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.016	0.031	-0.004	0.086	-319.4515	1070	○
		(0.02)	(0.02)	(0.02)	(0.06)			
SEVERE OBESITY	(A)	0.010		0.005	0.001	-94.953402	1124	-
		(0.01)		(0.01)	(0.02)			
		Naifs	Sophisticates					
	(B)	0.012	0.005	0.005	0.002	-92.263626	1105	-
		(0.01)	(0.01)	(0.01)	(0.02)			
	(A)	0.009		0.004	0.000	-90.166184	1089	○
		(0.01)		(0.01)	(0.02)			
		Naifs	Sophisticates					
	(B)	0.010	0.004	0.004	0.001	-87.606124	1070	○
		(0.01)	(0.01)	(0.01)	(0.02)			
UNDERWEIGHT	(A)	-0.017		-0.023	-0.040	-537.88229	1124	-
		(0.02)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	-0.029	-0.002	-0.026	-0.050	-515.34629	1105	-
		(0.03)	(0.03)	(0.03)	(0.06)			
	(A)	0.014		-0.007	-0.054	-519.56563	1089	○
		(0.02)		(0.03)	(0.06)			
		Naifs	Sophisticates					
	(B)	0.003	0.030	-0.011	-0.062	-497.24566	1070	○
		(0.03)	(0.03)	(0.03)	(0.06)			

Notes: The estimated marginal effects are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.

Appendix (d)
The marginal effects of time discounting on the health-related principal component (present bias dummy)

		Model	Present bias (α>0) = 1		Impatience (ρ)	Sign effect (θ)	R-squared	#obs	Controlled
HEALTHRELATED	All	(A)	0.292 ***		0.325 ***	-0.022	0.049	1773	-
			(0.06)		(0.06)	(0.16)			
			Naifs	Sophisticates					
		(B)	0.320 ***	0.216 ***	0.320 ***	-0.028	0.0476	1693	-
			(0.07)	(0.08)	(0.06)	(0.16)			
		(A)	0.126 **		0.161 ***	-0.084	0.2404	1739	○
			(0.05)		(0.06)	(0.14)			
			Naifs	Sophisticates					
		(B)	0.158 **	0.087	0.159 ***	-0.103	0.2375	1660	○
			(0.07)	(0.07)	(0.06)	(0.15)			
	Male	(A)	0.277 ***		0.302 ***	0.020	0.0402	826	-
			(0.09)		(0.09)	(0.21)			
			Naifs	Sophisticates					
		(B)	0.359 ***	0.121	0.299 ***	-0.003	0.0407	777	-
			(0.12)	(0.13)	(0.09)	(0.22)			
		(A)	0.093		0.164 **	-0.075	0.2275	810	○
			(0.08)		(0.08)	(0.20)			
			Naifs	Sophisticates					
		(B)	0.167	-0.015	0.160 *	-0.104	0.2262	762	○
			(0.11)	(0.11)	(0.08)	(0.21)			
	Female	(A)	0.282 ***		0.268 ***	-0.111	0.0468	947	-
			(0.06)		(0.08)	(0.21)			
			Naifs	Sophisticates					
		(B)	0.283 ***	0.290 ***	0.265 ***	-0.099	0.0485	916	-
			(0.08)	(0.09)	(0.08)	(0.21)			
		(A)	0.160 **		0.151 **	-0.094	0.1623	929	○
			(0.07)		(0.07)	(0.20)			
			Naifs	Sophisticates					
		(B)	0.165 **	0.177 **	0.157 **	-0.111	0.1611	898	○
			(0.08)	(0.09)	(0.08)	(0.21)			

Notes: The estimated coefficients are listed with robust standard errors in parentheses. Control variables include: the degree of risk aversion, age, gender, the university degree, household income, household real asset holding, household financial asset holding. *, **, *** represent statistical significances at the 10%, 5%, and 1% levels, respectively.